AMENDMENTS TO THE SPECIFICATION

Please replace the section of the specification titled "Brief Description of the Drawings" which begins on page 9 with the following amended section:

Several examples of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1a is a perspective view of an example of the radiographic equipment;

Figure 1b is a perspective view of a portion of the radiographic equipment shown in figure 1a;

Figure 1c is a sectional view along line A-A of ~~Figure,~~ Figure 1b;

Figure 2a is a schematic illustration of one module of the radiographic equipment's detector array;

Figure 2b is an end view of a scintillator illustrated in the detector array shown in Figure 2a, where the scintillator is surrounded by a mask having a first reflective surface;

Figure 2c is a schematic illustration of a further variation of the radiographic equipment's detector array;

Figure 3 is a bar graph of the calculated ratio, R, the ratio of the 14 MeV neutron to ^{60}Co gamma-ray mass attenuation coefficients for a large number of benign, narcotic and explosive materials;

Figure 4 is a plot of the calculated ratio, R, the ratio of the 14 MeV neutron to the ^{60}Co gamma-ray mass attenuation coefficients for a range of elements;

Figure 5a is a display output of a gamma-ray scan of a motor bike, ~~figure~~ Figure 5b is a display output in which the image is coloured according to the mass attenuation coefficient ratio, R, for 14 MeV neutrons and gamma rays;

Figure 6a is a schematic illustration of a selection of material samples and common objects arranged on wooden shelves; Figure 6b is a display output of a gamma-ray scan; Figure 6c is a display output in which the image is coloured according to the mass attenuation coefficient ratio, R, for 14 MeV neutrons and gamma rays;

Figure 7a is a schematic illustration of a selection of material samples, concealed contraband, alcohol, as well as simulated and real explosives; Figure 7b is a display output of a

gamma-ray scan; Figure 7c is a display output in which the image is coloured according to the mass attenuation coefficient ratio, R, for 14 MeV neutrons and gamma rays;

Figure 8a is a photograph of a ULD containing assorted household electronics metal items, concrete blocks and concealed contraband; Figure 8b is a display output of a gamma-ray scan; Figure 8c is a display output in which the image is coloured according to the mass attenuation coefficient ratio, R, for 14 MeV neutrons and gamma rays; Figure 8d is the display output of figure 8c which has been further processed to emphasise the organic material;

Figure 9a is a photograph of a ULD containing assorted household items and concealed drugs; Figure 9b is a display output of a gamma-ray scan; Figure 9c is a display output in which the image is coloured according to the mass attenuation coefficient ratio, R, for 14 MeV neutrons and gamma rays R; Figure 9d is the display output of ~~figure~~ Figure 9c which has been further processed to emphasise the organic material;

Figure 10a is a photograph of a ULD containing assorted household items and concealed drugs, Figure 10b is a display output of a gamma-ray scan; Figure 10c is a display output in which the image is coloured according to the mass attenuation coefficient ratio, R, for 14 MeV neutrons and gamma rays; Figure 10d is the display output of figure 10c which has been further processed to emphasise the organic material;

Figure 11 is a plot of a large number of benign, narcotic and explosive materials in terms of two cross-section ratios, namely 2.45 MeV neutron/14 MeV neutron cross-sections versus 14 MeV neutron/X- or gamma-ray cross-sections;

Figure 12a is a simulated count rate DT neutron image of a suitcase; Figure 12b is a simulated count rate image of a DD neutron image of the suitcase; Figure 12c is a simulated count rate X ray image of the suitcase; Figure 12d is a DT/X-ray cross section image and Figure 12e is a DD/DT cross-section image; ~~and~~

Figure 13a is a simulated 14 MeV neutron image of an air freight container; Figure 13b is an X-ray image respectively of the same container; and Figure 13c is a combined image of the same container; and

Figure 14 is a perspective view of a further example of the radiographic equipment.

Please replace the section titled "Best Mode for Carrying Out the Invention" which begins on page 11, with the following amended section:

Figure 1a illustrates the general layout of the radiographic equipment 10. The equipment 10 includes two separate generators of radiation, the first is an A-325 MF Physics neutron generator having a D-T neutron emitting module to produce a neutron energy source 12 having an energy of 14 MeV. The neutron generator is operated at a voltage of 80-110 kV. The second generator of radiation is a 0.82 GBq (or 22 mCi) ^{60}Co source 14 to produce a source of gamma-rays and is located to the right of and adjacent to the neutron generator. The neutron generator and ^{60}Co source 14 are situated within a collimating block in the form of a source shield housing 16.

A 1600 mm long and 20 mm wide detector array 18 is situated in the vicinity of the radiation source and is housed in a detector shield housing 20. The detector array 18, more clearly shown in figure 2a, is built up of eighty plastic scintillator rods 19 (of which only a portion are shown), each with a radiation receiving area of 20 mm x 20 mm, and a length of 75 mm. The radiation receiving area of each scintillator rod 19 corresponds to a single pixel in the image-frame. The term image frame is used to describe the two-dimensional array containing the number of counts measured in each pixel, accumulated over a fixed time interval. The scintillator rods 19 are made of an orange plastic scintillator in order to match the spectral response of the silicon photodiodes 21 to the respective plastic scintillators. The photodiodes 21 are optically coupled to respective scintillators 19 with optical cement. A reflective mask 31 (of which only one is illustrated) is painted on each of the orange scintillator rod and photodiode

combinations to minimise the loss of any light that escapes the scintillator rods. As illustrated in Figure 2b, each mask 31 has a first reflective surface 33 to reflect escaped light pulses back into the scintillator 19.

In the primary embodiment, the scintillation light produced in a rod 19 by an incident neutron or X- or gamma-ray is detected by a photodiode 21 attached to the end of the rod 19. In a first variation, light from a row or column of scintillator rods is collected by a wavelength shifting optical fibre and transmitted to the photodiode. By indexing the row and column producing the light pulse, the scintillator rod intercepting the radiation can be inferred. In a second variation, ~~light from a multiplicity of scintillator rods is collected by wave-length shifting or transparent optical fibre and directed to a position sensitive photodiode or multi-anode photomultiplier tube, to allow multiple scintillator rods to be read out by a single detector. In a third variation,~~ illustrated in Figure 2c, light from several rows or columns of scintillator rods 190 is collected by wave-length shifting optical fibres 40 and transmitted to a position sensitive photodiode or multi-anode photomultiplier 42. By indexing the row and column producing the light pulse, the scintillator rod intercepting the radiation can be inferred.

Since respective photodiodes 21 have no internal gain, the signal conditioning electronics 23 include preamplifiers used in conjunction with high-gain amplifiers in order to amplify the output signal for both neutrons and gamma-rays.

With reference to Figure 1a, a computer 15 is provided to generate output representing the mass distribution and composition of the object interposed between the sources 12, 14 and

detector array 18. A display screen 25 is further provided for displaying images based on the mass distribution and the composition of the ULD 28 being scanned.

The equipment 10 accommodates a ULD 28 with a width up to 2.5 m and a height of 1.7 m. Each ULD 28 to be imaged is mounted on a platform 30 that has runners to engage with a pair of tracks 32. In practice in an airport the ULDs could be scanned while still mounted on their respective dollies that are used to transport the ULDs around the airport. The ULDs and their dollies could be driven onto a platform that would traverse the radiation beams at a known speed. This would minimise the handling of ULDs at the airport.

A further shield in the form of a tunnel 34 is provided. The tunnel 34 is sufficiently long enough so that the equipment can be operated without doors on either end. This permits the number of ULDs passing through the equipment 10 to be maximised.

With reference to Figures 1b and 1c, ~~C~~collimating slits 38,39 ~~(not shown)~~ are cut into the source and detector shield respectively 16, 20, serve to define a fan shaped radiation beam 17, directed from the sources 12 and 14 towards the radiation detector 18. The detector collimating slit ~~38~~ 39 and detector 18 extend the full height of the tunnel 34. Slots (not shown) in the sides of the shield 34 are provided and mate with collimating slits and for the passage of radiation from the sources 12, 14 to the detector 18.

Each of the radiation shields 16, 20 and 34, attenuate and absorb both gamma rays and neutrons. Shielding materials used include concrete, iron and polyethylene. The radiation shields 16, 20 and 34 provide radiological protection for operators of the equipment or other persons in its immediate vicinity.

In operation, objects that are to be imaged are situated on the platform 30 that is then motorised through the tunnel 34. In the full-scale prototype scanner described here the platform 30 is typically operated at a speed such that each 10 mm increment takes approximately forty seconds to collect. This corresponds to a speed of 0.25 mm/sec; consequently, about 2½ hours are required to collect the image of a full ULD. In practice, the speed at which the ULD travels through the equipment can be increased by a factor of over one hundred by increasing the intensity of the neutron source and by increasing the area of the detector array.

As the object passes through the tunnel 34, a scintillation spectrum is collected separately for each element of the 80-pixel array. These spectra are read out and reset every time the platform 30 traverses 10 mm and the spectra are used to deduce neutron and gamma-ray count rates for each pixel. The information in each vertical strip is then assembled to form complete, 2-dimensional neutron and gamma-ray images.

The resulting image has a vertical resolution of 20 mm, governed by the pixel size, and a horizontal resolution of 10 mm, governed by the frequency with which the 80-pixel array is read out. As discussed below, deconvolution of the final image is performed to correct any blurring that may arise as a result of the combination of the motion of the platform 30 during the scan and the 20 mm width of the pixels.

Suppose that the neutron intensity and gamma-ray intensity transmitted though an object and detected in a particular pixel from each image are I_n and I_g respectively and that the neutron intensity and gamma-ray intensity transmitted and detected in a particular pixel from each image without an object present are I_{on} and I_{og} respectively.

Then the attenuation of essentially monoenergetic fast neutrons through an object of density ρ and thickness x can be calculated using the equation:

$$I_n/I_{on} = \exp(-\mu_{14}\, \rho\, x) \qquad (1)$$

Similarly the attenuation of essentially monoenergetic gamma ray attenuation through the object can be written as:

$$I_g/I_{og} = \exp(-\mu_g\, \rho\, x) \qquad (2)$$

where μ_{14} is the neutron mass attenuation coefficient at 14 MeV and μ_g is the gamma mass attenuation coefficient. The mass attenuation coefficient ratio can then be calculated directly:

$$R = \mu_{14}/\mu_g = \ln(I_n/I_{on}) / \ln(I_g/I_{og}) \qquad (3)$$

Where R is directly related to the composition of the object and allows a wide variety of inorganic and organic materials and elements to be distinguished.

Figures 3 and 4 illustrate the ability of R to distinguish a wide variety of inorganic and organic materials. Natural materials that are primarily carbohydrate based such as cotton, paper, wood as well as many foods, protein based natural materials such as wool, silk and leather and synthetic organic materials - mainly polymers can be broadly distinguished. As illustrated,

inorganic materials such as pottery, ceramics and metal items are easily distinguished from organic materials.

Due to the higher count-rates and lower background scattering of the gamma rays, the gamma-ray image carries most of the information about shape and density. For each pixel in the image, the quantity $\ln(I_g/I_{0g})$ is calculated, which is proportional to the total mass per unit area of material along the line from the radiation source to the pixel in question. A "Mexican-hat" sharpening filter is applied to this image to improve object definition and reduce the effects of the motion and pixel-size blurring that affects the horizontal resolution of the image.

The pixel-by-pixel ratio of the neutron and gamma-ray images carries information about the average composition of each pixel, which is independent of the amount of intervening material.

Due to the relatively low counting statistics in the neutron image, there is considerable pixel-to-pixel noise present in the composition image. Consequently, a 5×5-pixel Gaussian smoothing filter is applied to this image. Whilst this reduces the resolution of the composition information in the final image, it significantly enhances the visibility of subtle changes in composition for objects with dimensions of more than about 50 mm.

The results from six scans are shown in figures 5 to 10. The gray-scale images illustrate the results of the gamma-ray scan alone and as such show the results that would be achievable from a conventional X-ray scanner. Regions with little or no intervening material show as white and denser materials show as darker shades of grey. The colour images combine the gamma-ray shape and density information, together with the composition information from the

neutron/gamma ratio image. The density of colour shows the material density with white corresponding to no intervening material and denser regions having a saturated colour. The colour of a pixel corresponds to the R value for that pixel, with lower R values coloured blue, intermediate values turquoise through green to yellow and higher values orange. The exact mapping between R value and colour is different for each image, with the colour scale adjusted to show the maximum information in each case. For the ULD scans, an enhanced organic image is also presented. This emphasises organic regions of the image, which are coloured yellow, orange and red.

Figure 5a illustrates the result of the gamma ray scan alone of a motorbike. Figure 5b illustrates the combined gamma-ray shape and density information together with the composition information from the neutron/gamma ratio image scan of a motorbike. This image provides a good indication of the overall imaging capabilities of the equipment. In particular, fine details such as the front brake cables 52 show quite clearly in figure 5b, even though they are considerably smaller than the 20 mm pixel size. The metal frame 54 and engine 56 of the bike show up blue in figure 5b; whereas the fuel 58 in the petrol tank, rubber tyres 60, plastic seat 62 and plastic lights show up orange. The oil 64 in the sump (immediately above the kickstand), when averaged together with the metal around it shows as a green patch. In contrast, from the conventional gamma-ray image figure 5a, it is difficult or impossible to distinguish between the oil 64 and the sump.

Figures 6a to 6c illustrate a selection of material samples and common objects arranged on wooden shelves. Again, as illustrated in figure 6c, metals such as iron 66, lead 68 and

aluminium 70 show up dark-blue. Intermediate materials such as concrete 72, glass 74 (in the computer monitor 75) and ceramic powder (alumina, Al_2O_3) 76 show up lighter blue. Finally, the organic materials, including elemental simulants of heroin 77, methamphetamine 78, cocaine 80 and TNT 82 show up in a variety of colours from green to orange, depending on the R value of the material. Two ceramic statues on the top shelf, one filled with iron shot 84 and the other with sugar 86 can be clearly distinguished, both by density and by composition.

Figure 7a to 7c illustrate a further selection of materials, including concealed contraband, alcohol and both simulated and real (Detasheet) explosives. Three hollow concrete blocks are positioned on the top shelf. The left-hand block contains concealed organic material 94 (drug substitute); the centre block is empty and the right hand block contains alumina powder 96. These three blocks provide simple models of drugs concealed within a ceramic or pottery object, a hollow, empty object and a hollow, empty object with thickened walls. Whilst the gamma-ray image of figure 7b clearly distinguishes between the empty 95 and filled blocks 94 and 96, it cannot separate the drug-surrogate filled block 94 from the alumina filled block 96. In contrast, the neutron image of figure 6c clearly reveals the concealed organic filling 94 shown as a yellow/orange patch. On the left hand side of the middle shelf are positioned two containers, one filled with pure alcohol 98 (Meths) and one with water 100 (H_2O). The alcohol 98 shows clearly as being more 'organic' (higher R value) and is predominantly orange in colour; the water 100, with a lower R value is predominantly green. On the same shelf, the simulated 102 and real 104 explosives show as the same colour showing that the simulant is a good substitute for real explosive. On the bottom shelf is a case containing twelve glass bottles of which only four are

visible, two filled with simulated spirits 106 (40% ethanol, 60% water) and two filled with water 108. Again, the alcohol filled bottles 106 show up as having a higher R value (more green/orange) than the water 108 (predominantly blue). This is in contrast to the bottles shown in figure 7b which are almost indistinguishable.

Figures 8a to 8d, 9a to 9d and 10a to 10d illustrate the results of imaging ULDs filled with a variety of objects. In all three figures, the filling of the ULD has been deliberately kept fairly simple, to simplify discussion of the results obtained. In particular, most of the packing material that would normally be present (cardboard boxes, foam, polystyrene etc) has been omitted so that the objects in the ULD can be clearly seen. It is recognised that in reality, most ULDs would be considerably more cluttered.

Figures 8a to 8d illustrates a ULD filled with a variety of household electronics (a refrigerator 120 and several computers 122), metal parts, hollow concrete blocks 124 (substituting for ceramic pipes or hollow statues or figurines) and tools. Two packets of plastic beads, substituting for drugs 126, are concealed within one of the computers and inside one of the concrete blocks. A propane gas cylinder 128 is also hidden inside the ULD. Figure 8a illustrates a photograph of the ULD scanner. Figure 8b shows the results of the gamma-ray scan only. Neither of the packets of surrogate drugs 126 are particularly obvious. The propane gas cylinder 128 can be identified on the basis of its shape, although the organic nature of its contents is not clear. Figures 8c and 8d are coloured according to the neutron/gamma ratio R, as a result the inorganic materials show up in figure 8c as blue (<u>the computer 122 and blocks 124</u>~~the surrogate drugs 126 and the gas cylinder 128~~) and the organic materials as orange (the<u> surrogate</u>

drugs 126 and the gas cylinder 128 ~~computer 122 and blocks 124~~). The proportions in which the two images are combined are adjusted by the operator to maximise contrast and sensitivity for organic materials which are coloured yellow and red and to minimise the effects of clutter resulting from overlapping objects, the result is illustrate in figure 8d. Clearly both packets of concealed drugs 126 can be identified.

Figures 9a to 9d illustrates a ULD with drugs 124 concealed inside two computers 122 and a fridge 120. Whilst it can be seen in the gamma-ray image of figure 8b that the top two computers 122 appear somewhat different from the bottom two, it is not clear whether this is a genuine difference in the structure of the machines. However, in the figures of 9c and 9d it is immediately apparent that the difference is due to a large volume of organic material, as shown by the bright orange colour of these regions with drugs 124. The top two computers 122 contain ~1 kg bags of plastic beads simulating packaged drugs. This is in contrast to the predominantly blue (inorganic or low R value) colour of the rest of the computer structure 126. Similarly, it is not clear from the gamma-ray image of figure 9b of the fridge 120 whether the anomaly in the centre of the image is part of the structure of the fridge or not. However, in figures 9c and 9d it can be seen that the anomaly 124 is clearly organic and in contrast to the predominantly inorganic structure visible in the rest of the fridge (in particular, the compressor 125 at the lower right and the freezer compartment at the top). Again, in the enhanced organic image of figure 9d the concealed drugs 124 are clearly visible. Additionally, other organic material in the ULD (notably the wooden shelving 128 behind the fridge 120 and the container of water 127 to the left of the fridge 120) also shows up as orange.

Figures 10a to 10d illustrate a second ULD with real concealed drugs (1 kg each of heroin and methamphetamine). The heroin 130 is hidden inside a hollow concrete block 132. The methamphetamine 134 is hidden inside a small box, which is placed inside a larger box 136 filled with clothing. The organic nature of the concealed drugs is evident from the colouring in the composition images of figures 10c and 10d. Once again, the enhanced organic image of figure 10d effectively reveals the concealed drugs 130 and 134, especially the heroin 130 coloured yellow inside the concrete blocks 132. As the methamphetamine 134 is concealed within the box 136 of clothing (immediately behind the front fork of the bicycle 140), composition discrimination is less revealing in this case. However, the package of drugs 134 can be identified as a potential anomaly on the basis of its shape and higher density.

The radiographic equipment as described can be used in at least three ways for detecting and identifying contraband materials. Firstly, the gamma-ray images provide considerable information about the shapes, sizes and densities of objects inside an object such as a ULD. Some suspicious materials can be identified on this basis. Particular examples would be packets of drugs concealed inside spaces or cavities of hollow objects. Secondly, the colouring of the gamma-ray image on the basis of composition information derived from the neutron measurements provides powerful extra clues in the interpretation of scan images and identification of suspicious materials. In particular, the detection of organic materials inside predominantly inorganic objects is greatly facilitated. Thirdly, under certain circumstances, the equipment can be used to measure the neutron/gamma ratio (R values) of suspicious materials to further assist in their identification. This approach works best when there is little over- or under-

lying material around the substance being measured, or when the over- and under-lying material is reasonably uniform in the immediate vicinity of the measurement region. Under these circumstances, it is possible to make an approximate correction for the absorption of neutrons and gamma rays in the over- and under-lying material to obtain the R value of just the substance of interest.

A second embodiment applies directly to the dual energy fast neutron transmission embodiment for 14 MeV and 2.45 MeV. However the following discussion also applies to the dual energy transmission at different energies to 2.45 and 14 MeV. However unlike single energy neutron transmission discussed previously, three count rates are measured at each pixel rather than two in the case of single neutron transmission, and two-cross-section ratios can be calculated.

Suppose that the count rates in a particular pixel from each image are r_{14}, $r_{2.45}$ and r_X respectively. These rates are related to the (unknown) mass of material m between the source and detection points and the (unknown) mass attenuation coefficients of this material for 14 MeV neutrons, 2.45 MeV neutrons and X- or gamma-rays, written as μ_{14}, $\mu_{2.45}$ and μ_X respectively, by the relations:

$$r_{14} = R_{14}\exp(-m\mu_{14}) \quad (4)$$

$$r_X = R_X\exp(-m\mu_X) \quad (5)$$

$$r_{2.45} = R_{2.45}\exp(-m\mu_{2.45}) \quad (6)$$

where R_{14}, $R_{2.45}$ and R_X are respectively the count rates for 14 MeV neutrons, 2.45 MeV neutrons and X- or gamma-rays when no intervening object is present.

The cross-section ratios can be calculated directly:

$$\mu_{14}/\mu_X = \log(r_{14}/R_{14})/\log(r_X/R_X) \quad (7)$$

$$\mu_{2.45}/\mu_{14} = \log(r_{2.45}/R_{2.45})/\log(r_{14}/R_{14}) \quad (8)$$

Note that both of these ratios are independent of the mass of material present in the beam between the source and detector.

The cross-section ratios given by equations (7) and (8) allow a wide variety of organic and inorganic materials to be distinguished.

Figure 11 illustrates the ratio of 2.45 MeV neutron cross-section to 14 MeV neutron cross-section versus the ratio of 14 MeV neutron cross-section to X- or gamma-ray cross-section, for a selection of materials. The availability of two cross-section ratios further enhances the ability of the invention to distinguish between different materials. Consequently, analysis of the three mass-attenuation coefficient images allows information about the contents of the object being examined to be inferred.

Figure 12 illustrates the additional benefit of using dual neutron energies, consider the simulated images of a suitcase 150 shown in Figures 12a to 12e. Images 12a to 12c correspond to equations (4) (5) and (6) and show the transmission of 14 MeV neutrons, 2.45 MeV neutrons and

X- or gamma-rays respectively. Images 12d to 12e correspond to equations (7) and (8) and show the DT/X-ray and DD/DT cross-sections respectively.

The suitcase 150 is filled with clothing composed of cotton and wool, and contains various benign and suspicious objects. Bottle 152 contains water and bottle 154 contains spirits. The three blocks visible on the lower right of the suitcase 150 are a paperback book 156, heroin 158 and RDX explosive 160. A gun 162 is also visible in the upper right of the suitcase 150.

From a conventional X-ray image 12c, it is difficult or impossible to distinguish between the contents of the two bottles 152, 154, or the three packages 156, 158, 160 on the right hand side of the case that have similar densities. The neutron images 12a, 12b provide more contrast between the different materials, but the best results are obtained from the cross-section ratio images 12d and 12e. In particular, the book 156 as shown in figures 12a and 12b virtually disappears in figures 12d and 12e as paper has a similar composition to the surrounding clothing, whereas the drugs 158 in figure 12e and explosive materials 160 in figures 12d and 12e can be clearly distinguished. A clear difference is also seen in both figures 12d and 12e between the bottles containing water 152 and spirits 154.

In a first variation of the dual neutron transmission method, the operator would form a new image that is a linear combination of the two cross-section ratio images. The proportions in which the two images are combined are adjusted by the operator to maximise contrast and sensitivity for contraband materials and to minimise the effects of clutter resulting from overlapping objects.

Figures 13a to 13b illustrate simulated 14 MeV neutron and X-ray images respectively of a container 170, taken from the side. Due to their high density, the steel pipes 176 dominate the images, making it hard to see the outlines of the computer equipment. However, by forming a single image, figure 13c, from the two cross-section ratio images given by equations (7) and (8), it is possible to remove the "clutter" associated with the steel pipes 176, to reveal the computer boxes 174.

This approach can be understood with reference to Figure 11. Choosing a linear combination of images (7) and (8) is equivalent to colouring image pixels according to their distance from an arbitrarily orientated line drawn on Figure 11. By choosing this line to be parallel to two selected materials, any combination of these materials is coloured the same. In the example discussed, the line is chosen to be parallel to a line connecting steel and the polystyrene packaging of the computers. In this way, the steel pipes can be made to largely vanish where they pass in front of the computers. Figure 13c shows the results of this process.

Although one such example of the invention has been discussed, it should be appreciated that such an embodiment is only one of the many utilising the principles of the invention. Whilst in the above example, the radiation sources are situated on one side of the object to be examined and the detectors on the opposite side, in a first variation, the sources are situated above or below the object to be examined, with the detectors positioned on the opposite side (below or above respectively). In a second variation, the sources and detectors can be rotated around the object to be examined to allow multiple views to be obtained. In a third variation, multiple sets of sources and detectors are used to allow simultaneous collection of multiple views of the same object. In a

fourth variation, multiple sets of detectors are disposed around a central source to allow views of multiple objects to be acquired simultaneously.

Of course, in operation, objects that are to be scanned may be passed through the tunnel on a conveyor belt or winched or pushed through using a suitable mechanism.

Whilst in the above embodiment, the two radiation sources are operated sequentially as the object is scanned through the analyser. In a first variation, the object is scanned through the analyser twice, with one source being operated for each scan. In a second variation, each source has a separate associated detector and the object is scanned only once. In a third variation, the two radiation sources are operated at the same time, a single detector is used and energy discrimination is used to separate the signals due to neutron and X- or gamma-rays.

In the variation (dual neutron energy embodiment 100) as illustrated in Figure 14, the radiation source comprises three separate generators of radiation, one producing 14 MeV neutrons 112, one producing 2.45 MeV neutrons 113, and the last producing high-energy X- or gamma-ray radiations 114. The neutron sources are sealed tube neutron generators or other compact sources of a similar nature, producing neutrons via D-T and D-D fusion reactions.

The three radiation sources are operated sequentially as the object is scanned through the analyser. In a first variation, the object is scanned through the analyser three times, with one source being operated for each scan. In a second variation, each source has a separate associated detector (designated generally as 118) and the object is scanned only once. In a third variation, two or more of the radiation sources are operated at the same time with a single detector, and

energy discrimination is used to distinguish the signals from the high energy neutrons, low energy neutrons and X- or gamma-rays.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.